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Project LANDSAT D

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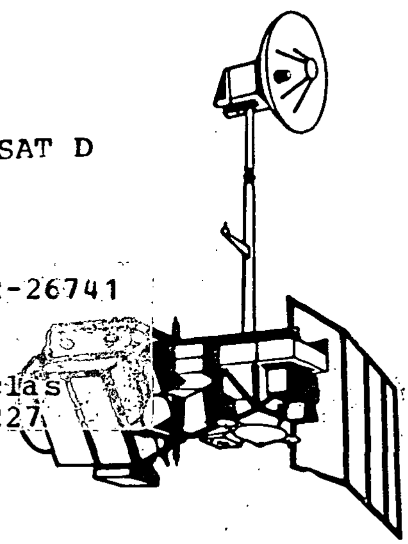

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RELEASE NO: 82-100

LANDSAT D TO TEST THEMATIC MAPPER, INAUGURATE OPERATIONAL SYSTEM

NASA will launch the Landsat D spacecraft, a new generation Earth resources satellite, from the Western Space and Missile Center, Vandenberg Air Force Base, Calif., no earlier than 1:59 p.m. EDT July 9, 1982, aboard a new, up-rated Delta 3920 expendable launch vehicle.

Landsat D will incorporate two highly sophisticated sensors: the flight proven multispectral scanner (MSS), one of the sensors on the Landsat 1, 2 and 3 spacecraft; and a new instrument expected to advance considerably the remote sensing capabilities of Earth resources satellites. The new sensor, the thematic mapper (TM), provides data in seven spectral (light) bands with greatly improved spectral, spatial and radiometric resolution.

Following an orbital and ground system checkout and transition period, the data from the multispectral scanner and the operation of the Landsat D spacecraft itself will be turned over to the Department of Commerce's National Oceanic and Atmospheric Administration for operational management.

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The orbital altitude of the spacecraft will be 705 kilometers (438 statute miles) at a 98.2 degree inclination to the equator. Landsat D, to be called Landsat 4 once it is in orbit, will circle the Earth every 98.9 minutes. In its orbit, the spacecraft will image the same 185 km (115 mi.) swath of the Earth's surface every 16 days. During the 16-day cycle, any part of the Earth, except for a small area immediately around the poles, can be imaged by the instruments aboard.

The Landsat D program, managed for NASA's Office of Space Science and Applications, by the Goddard Space Flight Center, Greenbelt, Md., has three major objectives:

- To provide continuing Earth remote sensing information and to encourage continued national and international participation in land remote sensing programs;
- To assess the capabilities of the new thematic mapper sensing system and to exploit new areas of the infrared and visible light spectrum at higher resolution; and
- To establish a technical and operational proficiency which can be used to help define the characteristics necessary for potential future operational land remote sensing systems.

Because of the proven value of the Landsat series, which NASA has flown as experiments in remote sensing, the Landsat D will become the first interim operational remote sensing satellite. It will be turned over to NOAA on Jan. 31, 1983. NOAA will then be responsible for controlling the spacecraft, scheduling the use of the sensors, data processing and distributing the data through the Department of Interior's Earth Resources Observation System (EROS) Data Center in Sioux Falls, S.D. NASA will continue to be responsible for the data processing until January 1985.

Although designed to use the tracking and data relay satellite system (TDRSS), the Landsat D will use the ground stations associated with the ground spacecraft tracking and data network (GSTDN) until the TDRSS is launched aboard a Space Shuttle in 1983.

Communications from the GSTDN stations are routed to the Landsat D ground processing center at Goddard Space Flight Center. Communications from the TDRSS will also be routed through Goddard once the TDRSS is operational.

The Landsat D makes continued use of the NASA standard multimission modular spacecraft (MMS). This spacecraft platform, also used on the Solar Maximum Mission spacecraft now in orbit, consists of four subsystems which provide for spacecraft operations. These subsystems are the electrical power system, attitude control system, data system, and propulsion system.

Landsat D will also use the global positioning system (GPS) for orbital position information. This is a new U.S. Air Force satellite navigation system involving orbiting navigational satellites to triangulate the exact position of other satellites which require navigation information as part of their data communications to Earth stations.

Landsat D is the fourth in the NASA Earth resources satellite series. Landsat 1 (originally called ERTS, or Earth Resources Technology Satellite) was launched July 1972. Landsat 2 was launched January 1975 and Landsat 3 was launched March 1978. Landsat 1 was removed from service early in 1978 after nearly six years of successful operation. Landsat 2 operations were terminated in February 1982 because of a malfunction in the attitude control system. Landsat 3 is still operating, although its primary sensor, the multispectral scanner (MSS), is limited in its capability to record Earth imagery due to the absence of an optical pulse which indicates the beginning of each scan line.

The degradation of the optical pulse has reduced the width of each Landsat 3 image by approximately 30 percent. Continuous Earth coverage, however, is still possible for areas above and below 35 degrees latitude.

Assuming satisfactory Landsat D multispectral scanner operations, Landsat 3 operations will be terminated and the satellite will be placed in an orbital standby mode in March, 1983.

As the next generation Earth resources satellite, Landsat D is designed to satisfy continuing requirements for timely, accurate and reliable data on Earth's resources. The requirements come from government agencies, research institutions and other organizations or individuals seeking information to assist in oil and mineral exploration; agriculture, forestry and water management; map making; industrial plant site identification and location; and general land use planning.

During the nine years of Landsat operations, the program has become increasingly popular internationally as well as domestically as a source of local, regional and global information. There are 11 nations which have their own capability to receive and process data directly from the satellite. In addition, more than 100 nations make some use of Landsat data for their resource development and management.

An identical backup spacecraft, Landsat D' (D prime), is part of the program. Landsat D' will be available for launch in July 1983. If not required for backup to Landsat D, it will be placed in storage and launched after Landsat D no longer functioning satisfactorily.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

THE LANDSAT STORY

America's Remote Sensing Experiment

The Past

Over the past decade the Landsat series of satellites and their primary Earth observing instrument, the multispectral scanner, have provided a wealth of observations that have improved our ability to monitor and understand the dynamics and character of the various features and materials covering the surface of the Earth. The multispectral scanner is a radiometer, an instrument that collects and measures the energy reflected or emitted in discrete intervals of the electromagnetic spectrum.

The multispectral scanner monitors the reflected solar energy in the green, red and near infrared parts of the spectrum. By using this multispectral capability, the Landsat observations have shown that it is possible to apply objective, automatic data processing techniques to delineate rapidly and efficiently the extent and condition of a wide variety of vegetation types, bare soil and rock conditions, snow cover and water bodies over large areas on a highly repetitive basis, and to do this in a cost effective manner.

Renewable Resources

Data from the multispectral scanner has been used extensively over the past 10 years for agriculture, forestry, range, water and land cover applications. Combining the spatial resolution of the multispectral scanner 80 m (262.4 ft.) with the four band (0.5 - 0.6, 0.6 - 0.7, 0.7 - 0.8 and 0.8 - 1.1 microns) multispectral capability just described, a basic and highly useful remote sensing spaceborne observation technique for identifying crop type, phenological state of development, areal extent and condition assessment has been established.

Spectral measurements have also been found to be useful in determining biophysical characteristics useful in crop yield (at harvest) modeling. The joint NASA/Department of Agriculture/NOAA large area crop inventory experiment (LACIE) conducted from 1975 through 1978 developed multispectral scanner and meteorological satellite capabilities for forecasting wheat production which were successfully tested in the United States and the Soviet Union.

This program was based on U.S. Department of Agriculture's (USDA) interest in remote sensing techniques for a broad array of domestic and foreign crop reporting information needs. Following the success of LACIE, a new interagency (NASA, USDA and NOAA) joint research effort was begun in 1980 called agriculture and resource inventory surveys through aerospace remote sensing (AgRISTARS).

Crop production forecasting research using the multispectral scanner was extended to multiple crops in multiple countries including corn and soybeans in Brazil and Argentina, and small grains in Australia. This effort has also relied on the use of multispectral scanner data in the development and testing of improved techniques for renewable resources surveys.

The agencies within the USDA which are now actively using multispectral scanner data include the Foreign Agricultural Service, Crop Condition Assessment Division; the Statistical Reporting Service, Domestic Crop Assessments Division; the Soil Conservation Service; Agricultural Research Service and the Forest Service.

Forest inventory, monitoring and condition assessment techniques have been successfully tested with multispectral scanner data. The St. Regis Paper Company is presently using multispectral scanner data in a forest resource information system after successfully testing the use of the data in its forests in the southeastern United States. More recently, NASA and the Pennsylvania Department of Environmental Resources have been testing the use of multispectral scanner data for monitoring insect defoliation of hardwood forests caused by gypsy moth infestations.

Range inventory and monitoring technique development and testing have been successfully conducted by the Department of Interior's Bureau of Land Management. After extensive testing with multispectral scanner data in specific ecosystems of Alaska, California, Arizona and Idaho, the Bureau has implemented a computer processing system based on these results which combine Landsat, aircraft and ground-based information to produce resource maps to aid them in their management of approximately 160 million hectares (400 million acres) of federal land.

Surface water delineation and snow cover area mapping have also been successfully demonstrated through the use of multispectral scanner data. The Corps of Engineers (U.S. Army) has found that Landsat-derived surface water maps are useful for conducting dam inspections. The California and Colorado Departments of Water Resources, in cooperation with the Soil Conservation Service, have found that multispectral scanner-based snow cover mapping can improve snowmelt runoff predictions.

Land cover classifications have been performed extensively with multispectral scanner data to generate land cover maps. Many states have incorporated multispectral scanner data processing capabilities including Georgia, South Dakota and Texas. These maps have served as useful planning tools in areas such as urban land-use delineation and hydrologic land use planning for urban water runoff estimation and erosion hazard assessment.

Non Renewable Resources

The use of Landsat multispectral scanner imagery in the search for new deposits of oil and mineral resources has grown enormously over the past decade. Many major oil and gas companies have developed internal computer capabilities for the analysis and interpretation or orbital imagery. Several companies maintain extensive libraries of Landsat data to assist them in their worldwide exploration activities. At the same time, many smaller companies that provide geophysical services to larger oil and mineral exploration firms have broadened their product line to offer Landsat imagery and image interpretations to their customers. In sum, Landsat data has become something of a standard tool in Earth geological prospecting.

Geologists use Landsat imagery in several different ways to learn more about the composition and structure of the Earth's crust. Multispectral imagery is commonly used to recognize areas where rock and soil is exposed at the surface and to detect certain differences in the mineral composition of these geological materials. Landsat imagery is also used in a more conventional photogeologic manner to measure the attitude of sedimentary rock units, to detect folds and faults in the Earth's crust and to estimate displacement along geological fractures. These different types of information can be displayed together on geological maps and provide great insight into areas which may have high resource potential.

Many popular accounts of geological applications of Landsat imagery often indicate that Landsat data can be used to produce conventional geological maps more efficiently or to locate sources of undiscovered mineral deposits. Such accounts are misleading because they do not accurately represent the manner by which Landsat data is employed in geological prospecting. Rarely is any single technique individually responsible for the discovery of a mineral deposit. Landsat data can play an important role in the development of a regional exploration strategy and in specifying target areas for more detailed mapping and geophysical studies. It is this latter usefulness which makes Landsat data such an efficient tool since it can often reduce the actual exploration time by helping to eliminate areas of low potential.

Landsat image analysis complements many conventional geological mapping techniques. These techniques are most useful for regional resource evaluation when combined.

Indirect Indications of Landsat Usefulness

Additionally, there are several other developments that help indicate the impact that Landsat has made. For example, the frequency of articles and illustrations using remotely sensed Earth data in the technical and scientific journals has increased many times over the past few years. A very large proportion of the remote sensing data cited is Landsat data.

The clear majority of textbooks in geology and geography published from the 1970s to the present use Landsat data to illustrate concepts. They also describe the Landsats as "tools" for scientific and applied research studies. Another illuminating indicator is the large number of universities now offering graduate and undergraduate degrees in Earth remote sensing. Many recent post-graduate degrees have been earned using Landsat data as the observational evidence.

Landsat has been accepted as a scientific and educational vehicle for increasing our understanding of local and regional surface features and for the evolution of the Earth's surface.

Another index of the use of Landsat comes from the volume of sales from the Landsat public archive files at the Interior Department's EROS Data Center, Sioux Falls, S.D. During the years from 1973 through 1981 the dollar volume of Landsat data sales has increased an order of magnitude. The total amount of digital data sold has increased more than 40 times. This reflects the rise in the use of computer processing techniques to handle multispectral scanner data and to enhance its interpretability.

In 1981, 36 percent of all Landsat data was sold to private citizens and companies within the United States, 33 percent was sold to foreign interests and 12 percent was sold to U.S. educational or research institutions and state and local government agencies.

Foreign use of the Landsat data has grown rapidly also. There are more than 100 nations which now have used Landsat data to survey and inventory their natural resources. There are 12 facilities located now in foreign countries which can directly acquire and process the Landsat satellite data. Nearly all of the major land areas of the planet are covered by these facilities. Only a small portion of Asia, Central and South America and central Africa remain uncovered by current Landsat ground stations.

Several universities and private companies in foreign countries now offer scientific and applications analysis for Earth resource or environmental survey research using Landsat information.

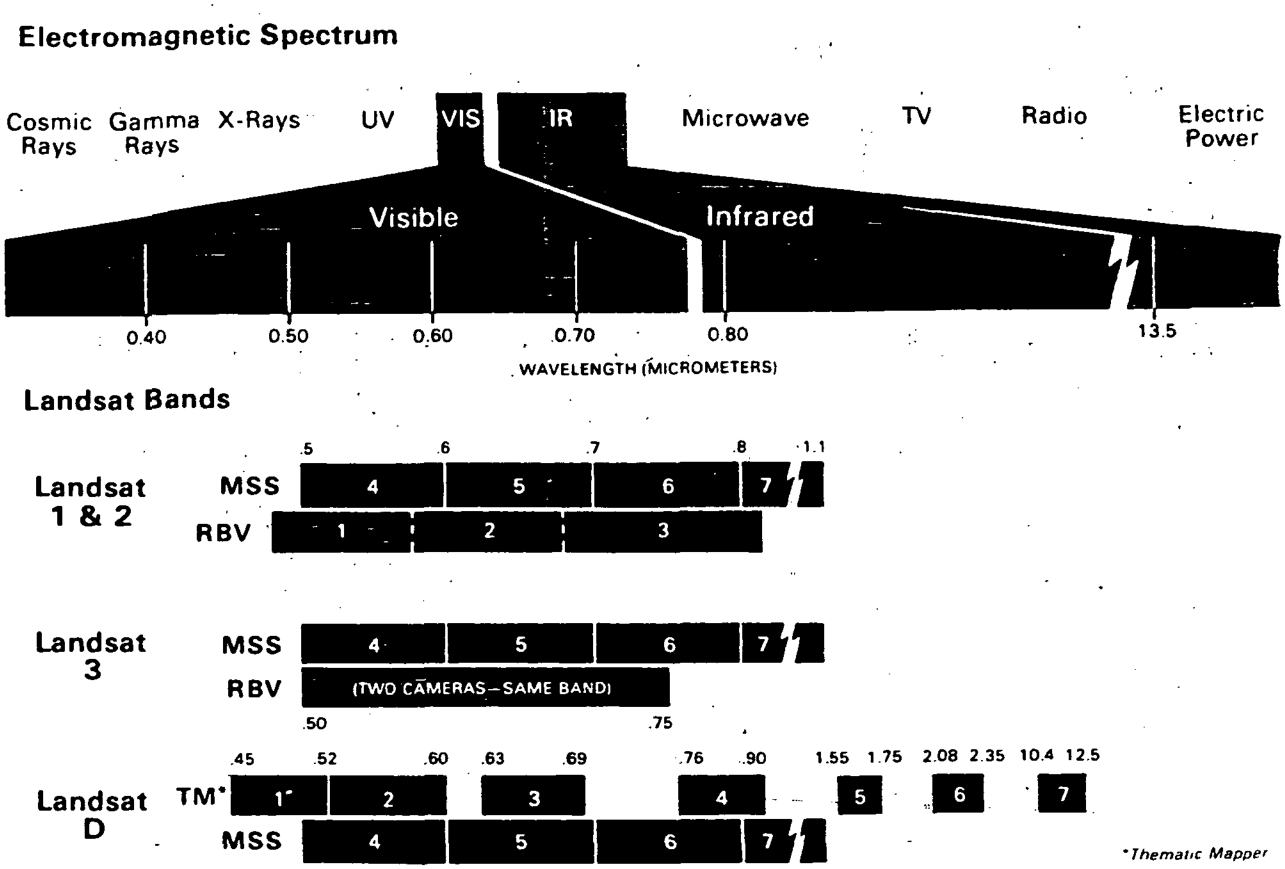
Japan, France, India and the European Space Agency (ESA) are presently investing in the development of national or continental remote sensing capabilities similar to or following up on the success of the Landsat program.

The Landsat program has been one of NASA's most widely successful experiments, particularly when viewed in the light of the international extent and usefulness of the information produced by the 10-year program.

The Future - From Multispectral Scanners to Thematic Mappers

Because of the tremendous success of the Landsat program, land use planners and managers are awaiting the Landsat D spacecraft because it will extend the data set of observations provided by the multispectral scanner for the past 10 years. This compilation of Earth surface information serves as a record of the transient and permanent changes associated with the continuing evolution of our planet. Landsat D insures that this valuable record is continued.

Earth resources investigators and a cross section of Earth scientists are awaiting Landsat D for a very different reason. This new spacecraft represents an aggressive observational experiment which will provide opportunities to check first hand the advantages of increased spatial resolution, of new narrower spectral bands, of a thermal energy channel and improved radiometric resolution. The instrumentation built into Landsat D's thematic mapper will be compared directly with the updated multispectral scanner instrumentation. The information from the two radiometric scanning instruments will then be subjected to comparative analysis in a variety of studies from agriculture to mineral exploration.



Applications of Spectral Bands

0.45 - 0.52 µM

- BATHYMETRY IN LESS TURBID WATERS; SOIL/VEGETATION DIFFERENCES; DECIDUOUS/CONIFEROUS DIFFERENTATION; SOIL TYPE DISCRIMINATION

0.52 - 0.60 µM

- INDICATOR OF GROWTH RATE AND VEGETATION VIGOR BECAUSE OF SENSITIVITY TO GREEN REFLECTANCE PEAK AT 0.55 µM, SEDIMENT CONCENTRATION ESTIMATION; BATHYMETRY IN TURBID WATERS

0.63 - 0.69 µM

- CHLOROPHYLL ABSORPTION/SPECIES DIFFERENTATION; ONE OF BEST BANDS FOR CROP CLASSIFICATION, VEGETATION COVER AND DENSITY; WITH THE 0.52 - 0.60 µM BAND IT CAN BE USED FOR FERRIC IRON DETECTION; ICE AND SNOW MAPPING

0.76 - 0.90 µM

- WATER BODY DELINEATION; SENSITIVE TO BIOMASS AND STRESS VARIATIONS

1.55 - 1.75 µM

- VEGETATION MOISTURE CONDITIONS AND STRESS; SNOW/CLOUD DIFFERENTATION; MAY AID IN DEFINING INTRUSIVE OF DIFFERENT IRON MINERAL CONTENT

2.08 - 2.35 µM

- DISTINGUISH HYDROTHERMALLY ALTERED ZONES FROM NON-ALTERED ZONES/MINERAL EXPLORATION; SOIL TYPE DISCRIMINATION

10.4 - 12.5 µM

- SURFACE TEMPERATURE MEASUREMENT; URBAN VERSUS NON-URBAN LAND USE SEPARATION; BURNED AREAS FROM WATER BODIES

The Thematic Mapper's Spectral Resolution

The unique and powerful advantages of the thematic mapper come in its multispectral observations. The experience gained in multiple agency experiments such as LACIE and AgRISTARS has shown that narrower spectral bands in the visible and near infrared portions of the electromagnetic spectrum are needed. These experiments have also shown that new spectral bands in the middle (1 - 3 micron) and far (4 - 20 micron) infrared are needed to distinguish between crops that appear very similar in multispectral scanner observations. Typically crops such as wheat and barley, or corn and soybeans can be confused when using multispectral scanner classification techniques.

The mineral and petroleum exploration scientists have also wanted new and narrower spectral bands so better geological surveying and exploration procedures could be tested using the advantages of a high altitude observation platform in space.

The thematic mapper uses significantly narrower bands in the green, red and near infrared compared to the multispectral scanner. These narrower bands allow the increased reflectance of vegetation in the green (0.52 - 0.6 micron vs. 0.5 - 0.6 micron) and near infrared (0.76 - 0.9 micron vs. 0.7 - 1.1 micron) to be measured more precisely by the thematic mapper. In the case of the near infrared, the narrower spectral band reduces the chance of obscuration of the land surface by water vapor in the atmosphere. A narrower band in the red region (0.63 - 0.69 micron vs. 0.6 - 0.7 micron) will allow differences in chlorophyll absorption associated with various plants to be distinguished better.

With these improvements the thematic mapper offers distinct advantages relative to the multispectral scanner for vegetation and land cover mapping.

	THEMATIC MAPPER (TM)		MULTISPECTRAL SCANNER (MSS)	
SPECTRAL BAND	MICROMETERS	RADIOMETRIC SENSITIVITY (NE△P) %	MICROMETERS	RADIOMETRIC SENSITIVITY (NE△P) %
1	0.45 - 0.52	0.8	0.5 - 0.6	.57
2	0.52 - 0.60	0.5	0.6 - 0.7	.57
3	0.63 - 0.69	0.5	0.7 - 0.8	.65
4	0.76 - 0.90	0.5	0.8 - 1.1	.70
5	1.55 - 1.75	1.0		
6	2.08 - 2.35	2.4		
7	10.40 -12.50	0.5K (NE△T)		
GROUND IFOV	30M (BANDS 1-6) 120M (BAND 7)		83M (BANDS 1-4)	
DATA RATE	85 MB/S		15 MB/S	
QUANTIZATION LEVELS	256		64	
WEIGHT	246 KG		58 KG	
SIZE	1.1 x 0.7 x 2.0M		0.35 x 0.4 x 0.9M	
POWER	345 WATTS		81 WATTS	

The major advantages of the thematic mapper for renewable resources and land cover studies, however, come from the addition of new spectral bands. A new band measuring reflected sunlight in the blue - green (0.45 - 0.52 micron) portion of the spectrum will allow further differences in chlorophyll absorption to be differentiated.

Natural color images of the Earth's surface features will now be possible for the first time on a Landsat. The multispectral scanner only allowed false color images where grass and vegetation often appeared red. The addition of the blue-green band on the thematic mapper will also be useful in allowing greater depths to be seen through relatively clear water. This is useful for bathymetric measurements first developed with the multispectral scanner. Coastal water bottom topography mapping, reef mapping, uncharted island surveying and atoll surveying are all possible new uses for the thematic mapper data.

The middle infrared bands of the thematic mapper (1.55 - 1.75 microns and 2.08 - 2.35 microns) are new and are expected to be particularly useful in vegetation mapping because of the sensitivity of these bands to the amount of water actually present in the plant leaves. Observations in these spectral bands should allow plants to be identified and differentiated based on their differences in leaf water content (succulency).

In addition to the plant identification characteristic, these middle infrared bands will also be useful in helping to assess plant health and condition based on its water content.

Because clouds often obscure snow covered fields, these middle infrared bands will also be useful in assisting in snow cover mapping. In these spectral bands snow appears as very dark while clouds remain quite bright. Multispectral scanner images could not detect the difference between clouds and snow cover.

The multispectral qualities of the thematic mapper will improve significantly the quality of geological maps produced from Landsat D data. The new infrared bands will permit geologists to spectrally differentiate a wider variety of rock and soil types. Experimental studies conducted during the development of the thematic mapper have shown that the two middle infrared bands will be most useful for detecting variations in the type and abundance of clay minerals exposed at the Earth's surface. Clay minerals can be formed as the result of surface weathering or they can be produced by subsurface hydrothermal alteration. Hydrothermal alteration occurs when heated, mineral rich groundwater circulates through existing rock. This process often accompanies the emplacement of specific mineral deposits such as copper, lead, zinc and uranium.

Thematic mapper data will also be able to distinguish hydrothermal clay minerals from other species in semi-arid regions and can potentially contribute to base metal exploration in certain geographies. This same clay mineral/clay delineation capability may also be useful for soil type mapping.

The emitted thermal energy band (10.4 - 12.5 microns) measures surface temperature. This capability will allow another fundamental dimension of multispectral data to be added to that already present in thematic mapper bands measuring reflected solar energy. By measuring the temperature of plants, the plant condition or health can be identified. Differences in the heat capacity characteristics of different plants will further improve the identification of individual plant types.

This same principal will be used for identifying and mapping surface composition for geologic studies. This band should allow differences in heat capacity (thermal inertia) to be used for mineral and petroleum exploration.

The real advantage of this new thermal energy band, however, is not truly understood and will have to await the Landsat D investigations.

Spatial Resolution

The thematic mapper will have a 30 by 30 m (98 by 98 ft.) instantaneous-field-of-view as compared to an 82 by 82 m (269 by 269 ft.) field-of-view in the Landsat D multispectral scanner or a 79 by 79 m (240 by 240 ft.) field-of-view for the Landsats 1, 2 and 3. The thematic mapper field-of-view covers an area one seventh the area of the multispectral scanner and will allow much smaller features on the surface to be identified and measured.

In the case of agricultural inventories the multispectral scanner was only able to monitor relatively large fields -- (1.6 hectares (40 acres) -- such as those in the North American Great Plains and the wheat producing regions of Northeastern Europe and Northern Asia.

The thematic mapper can inventory much smaller fields 2 to 4 hectares (5 to 10 acres) such as those in the eastern and southern United States and the small fields of China, India, Europe and South America.

For land use mapping and planning the thematic mapper spatial resolution should allow features which were blurred in multispectral scanner observations to be mapped much more easily and accurately. Urban planners concerned with changing land use patterns and hydrologists investigating storm water management should be able to use thematic mapper data much more effectively than multispectral scanner data.

The improved spatial resolution of the thematic mapper will also benefit geologic mapping. The 30-m (98-ft.) pixel (picture element, a single scan data point) of the thematic mapper will enable photointerpreters to detect smaller scale land forms and river channels. It will also permit geologists to recognize more isolated occurrences of specific rock types.

Radiometric Resolution

In order to measure subtle differences in reflected or emitted energy with a radiometer like the multispectral scanner and thematic mapper, it is important to be able to quantify differences in the measured energy over the entire dynamic range of the sensing instrument and to perform the quantization in as many discrete levels as practical (within limits imposed by the electronic noise generated by the system itself). The multispectral scanner measurements are broken into 64 levels. This level of quantization has allowed differences of reflected energy on the order of 1.5 percent to be measured. The thematic mapper and its associated electronics will permit each of the seven spectral bands to be quantized into 256 levels. The thematic mapper will be able to detect differences in reflected light energy as small as 0.5 percent. This represents a three-fold improvement which is expected to translate into a 10 to 20 percent improvement in the multispectral classification performance of the thematic mapper as compared to the multispectral scanner.

The Landsat D Image Data Quality Analysis Program

In order to assess the nearly two times improvement in spectral discrimination, the nearly three times improvement in spatial resolution and the three times improvement in energy sensitivity, the Landsat D program includes an investigation program established to assess the performance of all of the Landsat D systems, but particularly the thematic mapper. The Landsat D systems performance will be examined in light of the specifications established for them by the scientific, engineering and resource management communities. The performance and usefulness of the Landsat D multispectral scanner will be assessed.

The investigations program extends from 1982 through 1985 and at present involves 25 different investigations proposed by university, private industry, government agency and foreign scientists. Many of these investigations, including some from private industry, will be conducted at no cost to NASA due to the great interest generated by the potential application of the thematic mapper.

DESCRIPTION OF OPERATIONAL SYSTEM

NASA will launch Landsat D, check out the spacecraft systems, establish the precise orbit and demonstrate the system to be fully operational before transferring management to NOAA. The thematic mapper will remain an experimental development project under direct NASA (Goddard Space Flight Center) management. Public domain data from the mapper will be provided to NOAA for distribution.

Under the single manager approach adopted by the federal government, NOAA will be responsible for controlling the spacecraft, scheduling the sensors, processing and distributing data from the multispectral scanner and reproducing and distributing public domain data from the thematic mapper.

The Landsat D program is keyed to user requirements and reliable data product delivery.

Information from Landsat is produced from the multispectral scanner both as computer compatible (on tape) and in the form of imagery (photo product). Each Landsat scene covers an area of 185 by 185 km (115 by 115 mi.).

The multispectral scanner is essentially the same as those used on previous Landsat spacecraft. It acquires data simultaneously from four bands of the visible and near-infrared portions of the light spectrum. False color composite photos can be produced by combining several bands of information through filters onto color film.

The resulting pictures produce a great deal of useful data in color. Vegetation appears in various shades of red, depending on species, stage of growth and health of the plants. Cities and highways appear blue. Water comes out in shades from white through blue to black, depending on the depth, sediment load and other characteristics.

Data from the multispectral scanner will be received at the NOAA ground station facility developed by NASA, located at Goddard Space Flight Center, where it will be processed into a format suitable for archiving. The data will then be transmitted via communications satellite to the Department of Interior EROS Data Center for further processing into computer compatible tapes or pictures.

To provide service to Landsat customers, NOAA has entered into an agreement with Interior to continue EROS Data Center Landsat data activities under NOAA management. The NOAA Landsat activity at the center will be the hub for customer services.

Information similar to that produced by the multispectral scanner but in much greater detail will be produced by the thematic mapper.

The thematic mapper covers the same areas as the multispectral scanner but with finer resolution using seven bands of the spectrum. Data from the thematic mapper will be processed by NASA and scenes placed in the public domain by forwarding to the EROS Data Center for sale to the public.

PLANNING TO MEET USER NEEDS

In November 1979, NOAA was designated by the federal government to manage all operational civilian remote sensing activities from space. NOAA was selected as the operating agency because of its experience in managing and operating the National Environmental Satellite System, which has involved 24 environmental satellites since 1966.

A series of public meetings on Landsat, now in progress, is aimed at bringing the public up to date on the planned Landsat information system. These meetings are a continuation of a Landsat exchange program begun in early 1980 by NOAA which seeks to obtain advice from the public about how best to structure the multispectral scanner basic data set.

Establishment of the Landsat information system began with a series of five regional meetings in 1980 to request public assistance in its development. The meetings produced more than 700 responses from business firms, trade associations, educational institutions, state and local government agencies and private citizens.

Policy issues raised at the meetings included the types of instruments to be carried aboard the spacecraft, their capabilities, how quickly and in what form the data should be made available and how charges would be assessed.

NASA and NOAA jointly sponsored a series of conferences throughout the country in early 1981 to help plan a distribution system responsive to user needs. NASA-sponsored conferences reported the results of state and local government uses of Landsat data for natural resource and environmental monitoring. NOAA-sponsored conferences, held after the ones by NASA, described some of the products and services possible.

In December 1981, NOAA announced a new service providing special acquisition of Landsat data not regularly scheduled for sensing and new prices for Landsat products. This new Landsat service was created to meet a longstanding demand from certain users for collection and rapid distribution of multispectral scanner data for Earth locations not scheduled for routine collection.

MISSION DESCRIPTION

Landsat D will be launched on a Delta 3920 vehicle into a circular, near polar, Sun-synchronous orbit. The launch time is selected to achieve a descending node equatorial crossing between 9:30 and 10:00 a.m. local time. The nominal orbital altitude will be 705 km (380 n. mi.) at a 98.2 degree inclination with a 16-day repeat cycle and a period of 98.9 minutes.

The spacecraft is contained in the 2.2-m (86-in.) diameter shroud envelope of the Delta at launch. The 1.8-m (6-ft.) relay satellite tracking antenna is stowed in the forward shroud area extending into the conical portion of the shroud. The rear of the antenna assembly is preloaded to the antenna boom and forward portion of the spacecraft structure to provide a rigid tie-down during launch.

The solar array assembly is stowed for launch between the upper spacecraft support structure and the Delta shroud. The panels are rigidly tied to the primary spacecraft structure at four locations during launch.

Landsat D will be imaging the same 185-km (115-mi.) swath of the Earth's surface every 16 days. During this 16 day cycle, the entire Earth, except for small areas around both poles, can be imaged.

Image data will be transmitted in realtime at Ku band via the Tracking and Data Relay Satellite once it is launched in 1983. Once the Landsat D begins using the TDRSS, communication will be through the relay satellite ground station at White Sands, N.M. Thematic mapper data will be recorded at the ground station and then relayed to Goddard via communications satellite. Multispectral scanner data can be either recorded at the White Sands station and relayed to Goddard or relayed in real time to Goddard for processing.

Until the TDRSS is operational, the downlink communications mode for MSS data will be through the Landsat D direct access S band link. The S band is also provided for compatibility with existing Landsat 1, 2 and 3 ground stations in foreign countries. Thematic mapper data can be transmitted directly to the ground at X band before the TDRSS is operational. The X band can be used instead of or in addition to the Ku band TDRSS communications modes.

Spacecraft telemetry and command communications are through the S band system, either directly through the TDRSS (when available) or through the existing ground spacecraft tracking and data network (managed by Goddard).

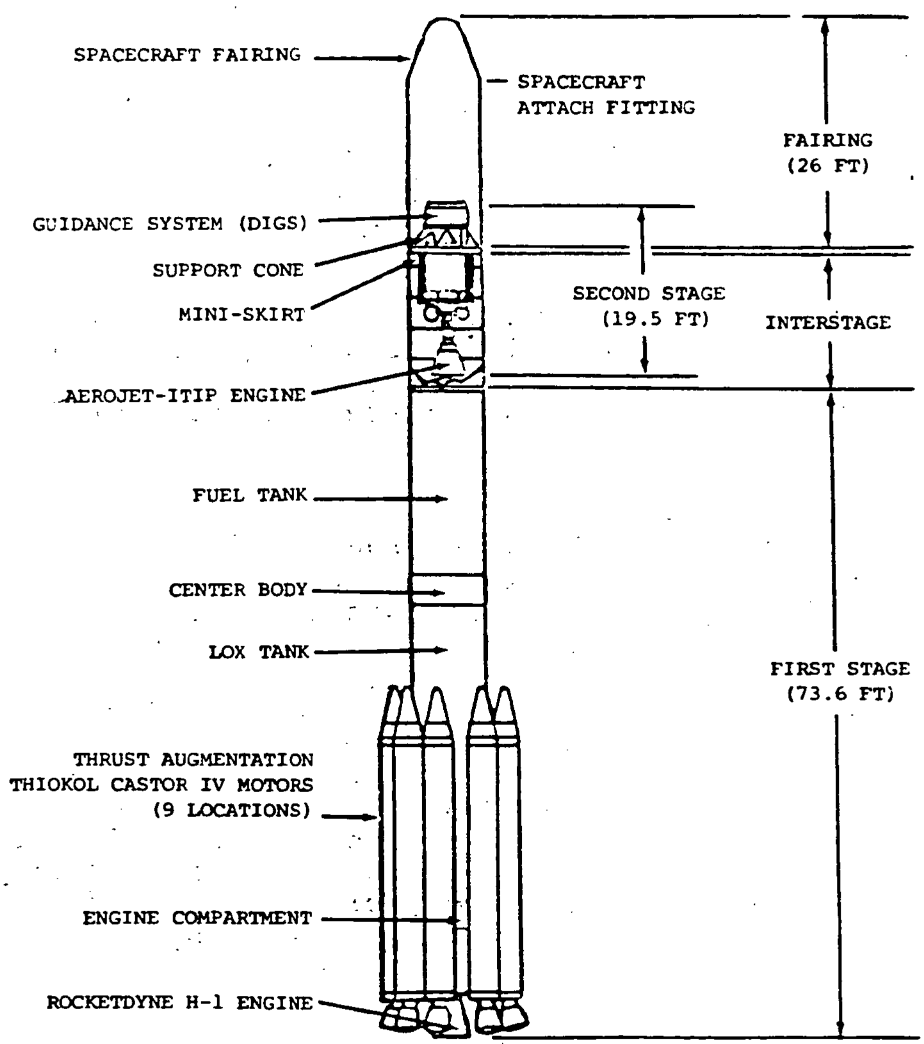
U.S.-required foreign multispectral scanner data will be acquired at four foreign receiving stations and sent to the United States. The four stations are in Sweden, Brazil, Japan and Australia. Data tapes acquired at those stations will be processed at Goddard after receipt.

Ephemeris data, required for spacecraft control and for ground processing and image correction is computed by Goddard. Following the checkout of the system, ephemeris will be available through the Landsat D directly, using the global positioning system receiver.

LAUNCH VEHICLE DESCRIPTION

The Landsat D spacecraft will be the first mission launched by the new Delta 3920, which is a thrust-augmented NASA Delta 3910 launch vehicle. This will be the 163rd flight for Delta. Of the previous 162 flights, 149 have successfully placed their satellite payload in orbit.

DELTA 3920 VEHICLE COMPONENTS



DELTA 3920 LAUNCH VEHICLE CHARACTERISTICS

	STRAP-ON	STAGE I	STAGE II
Length	11.3m (37.0 ft)	21.3m (70.0 ft)	700.0cm (276 in)
Diameter	101.6 cm (40 in)	243.3 cm (96 in)	175.3 cm (69 in)
Engine Type	Solid	Liquid	Liquid
Engine Manufacturer	Thiokol	Rocketdyne	Aerojet
Designation	TX-526	RS-27	ITIP
Number of Engines	9	1 (+2VE)	1
Specific Impulse Avg.	229.9	262.4	319
Thrust (per engine)(Avg.)	407,000 N (91,520 lb)	911,840 N (205,000 lb)	41,969 N (9,443 lb)
Burn Time	58.2 (sec)	228 (sec)	445 (sec max)
Propellant	TP-H-8038	RP-1 (LOX oxid.)	A-50 (N_2O_4 oxid.)

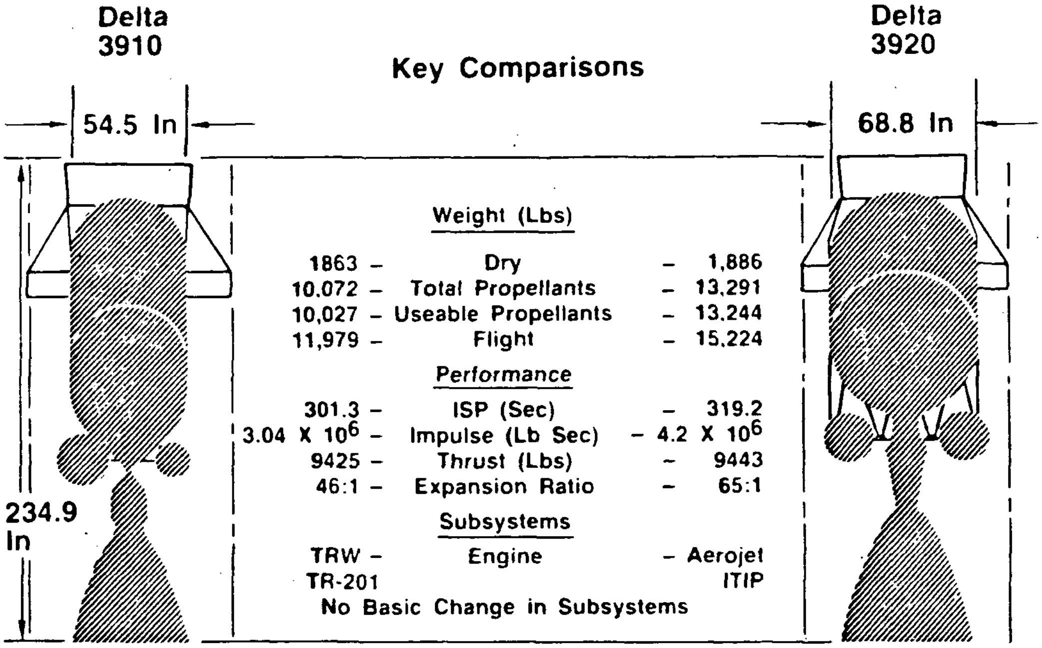
Delta is managed for NASA's Office of Space Transportation Operations by the Goddard Space Flight Center. Launch operations management is the responsibility of the Kennedy Space Center, Fla.

The Delta 3920 is 35.5 m (116 ft.) long, including the spacecraft shroud. Liftoff weight is 189,087 kg (415,990 lb.) and liftoff thrust is 2,058,245 newtons (547,504 lb.) including the startup thrust of six of the nine strap-on solid rocket motors (the remaining three motors are ignited at liftoff plus 60 seconds).

The first stage booster will be an extended long-tank Thor powered by the Rocketdyne RS-27 engine. This engine uses hydrazine (RP-1) fuel and liquid oxygen oxidizer. Pitch and yaw steering is provided by gimballing the main engine. Vernier engines provide roll control during powered flight and coast.

The Delta 3920 incorporates a new second stage consisting of large diameter propellant tanks coupled with the new Aerojet Liquid Rocket Company's AJ-10-118 improved transtage injector program (ITIP) engine. This stage is powered by a liquid propellant engine using N_2O_4 as oxidizer and Aerozene 50 as fuel. Pitch and yaw steering during powered flight is provided by gimballing the engine. Roll steering during powered flight and coast is provided by a nitrogen gas thruster system.

DELTA 3920 SECOND STAGE COMPARISONS



Key Comparisons

Delta 3910		Delta 3920
	Weight (Lbs)	
1863	Dry	1,886
10.072	Total Propellants	13.291
10,027	Useable Propellants	13.244
11,979	Flight	15.224
	Performance	
301.3	ISP (Sec)	319.2
3.04 X 10^6	Impulse (Lb Sec)	4.2 X 10^6
9425	Thrust (Lbs)	9443
46:1	Expansion Ratio	65:1
	Subsystems	
TRW TR-201	Engine	Aerojet ITIP
	No Basic Change in Subsystems	

The guidance and control system of the Delta vehicle is located on top of the second stage. The strap down Delta inertial guidance system (DIGS) provides the guidance and control signals for the total vehicle from liftoff through attitude orientation. The system is composed of a digital computer provided by Delco (General Motors Corp.) and either the inertial measurement unit (IMU) provided by Hamilton Standard (United Technologies) or the Delta redundant inertial measurement system (DRIMS) developed by McDonnell Douglas Astronautics Co.

First and second stage telemetry systems are similar, both combining the use of pulse duration modulation and frequency modulation. Critical vehicle functions are monitored during ascent.

At liftoff, six Castor IV solid rocket motors are ignited on the launch pad and burn out at 57.8 seconds. At 60 seconds the remaining three solids are ignited and burn out at 118 seconds. The six ground-lift solid motors are jettisoned in groups of three at 78 and 79 seconds with the final set jettisoned at 123.5 seconds. Main engine cutoff (MECO) occurs at 226.6 seconds. First stage separation occurs at 234.6 seconds with the spacecraft fairing jettisoned at 245 seconds.

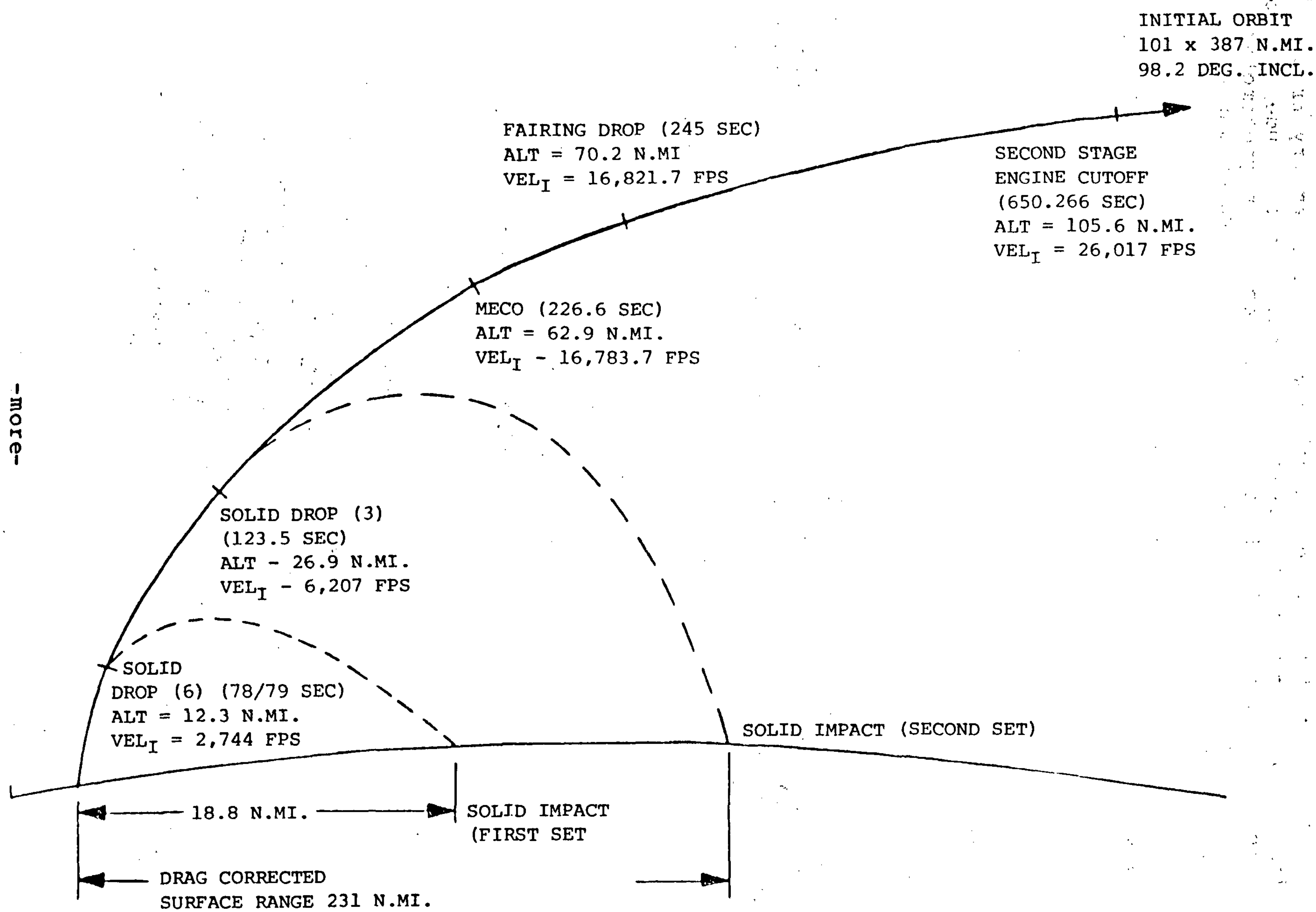
At second stage cutoff (SECO) the vehicle is at an altitude of 196 km (105 n.mi.) and on an orbital trajectory with an apogee of approximately 716 km (387 n.mi.) and a perigee of 187 km (101 n.mi.) At first apogee the second stage is restarted and burns for 15 seconds to circularize the orbit at 696 km (376 n. m.).

-more-

LANDSAT D FLIGHT SEQUENCE OF EVENTS

EVENT	TIME (SEC)
LIFT-OFF	0.0
6 SOLID BURNOUT	57.8
3 SOLID IGNITION	60.0
SEPARATE 3 SOLIDS	78.0
SEPARATE 3 SOLIDS	79.0
3 SOLID BURNOUT	118.0
SEPARATE 3 SOLIDS	123.5
MAIN ENGINE CUTOFF (MECO)	226.6
STAGE I-II SEPARATION	234.6
STAGE II IGNITION	239.6
JETTISON FAIRING	246.0
FIRST CUTOFF - STAGE II (SECO 1)	650.3
BEGIN MANEUVER TO COAST ATTITUDE	700.0
COMPLETE MANEUVER TO COAST ATTITUDE	955.0
RESTART STAGE II	2890.6
SECOND CUTOFF - STAGE II (SECO 2)	2905.2
BEGIN MANEUVER TO SPACECRAFT SEPARATION ATTITUDE	2940.0
COMPLETE MANEUVER TO SPACECRAFT SEPARATION ATTITUDE	3130.0
SPACECRAFT SEPARATION, ACTIVATE RETRO SYSTEM	3197.1
FIRST DESCENDING NODE (FOLLOWING INJECTION)	6578.9

LANDSAT-D BOOST PROFILE



SPACECRAFT ACTIVATION

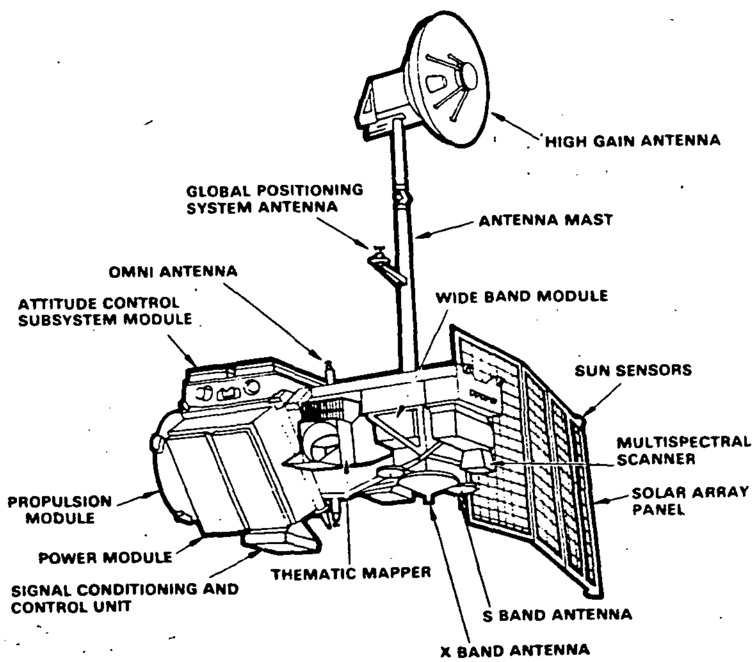
The Landsat D will be launched with one telemetry transmitter and one command receiver activated. The attitude control system will have the Earth sensors, Sun sensors, magnetometers, magnetic torquers, gyros and reaction wheels powered during launch.

One telemetry tape recorder will be recording and the onboard telemetry processing computer will be activated. Separation from the launch vehicle will occur during the first orbit over the Indian Ocean when in view of the Department of Defense Indian Ocean tracking station, about 53 minutes after launch.

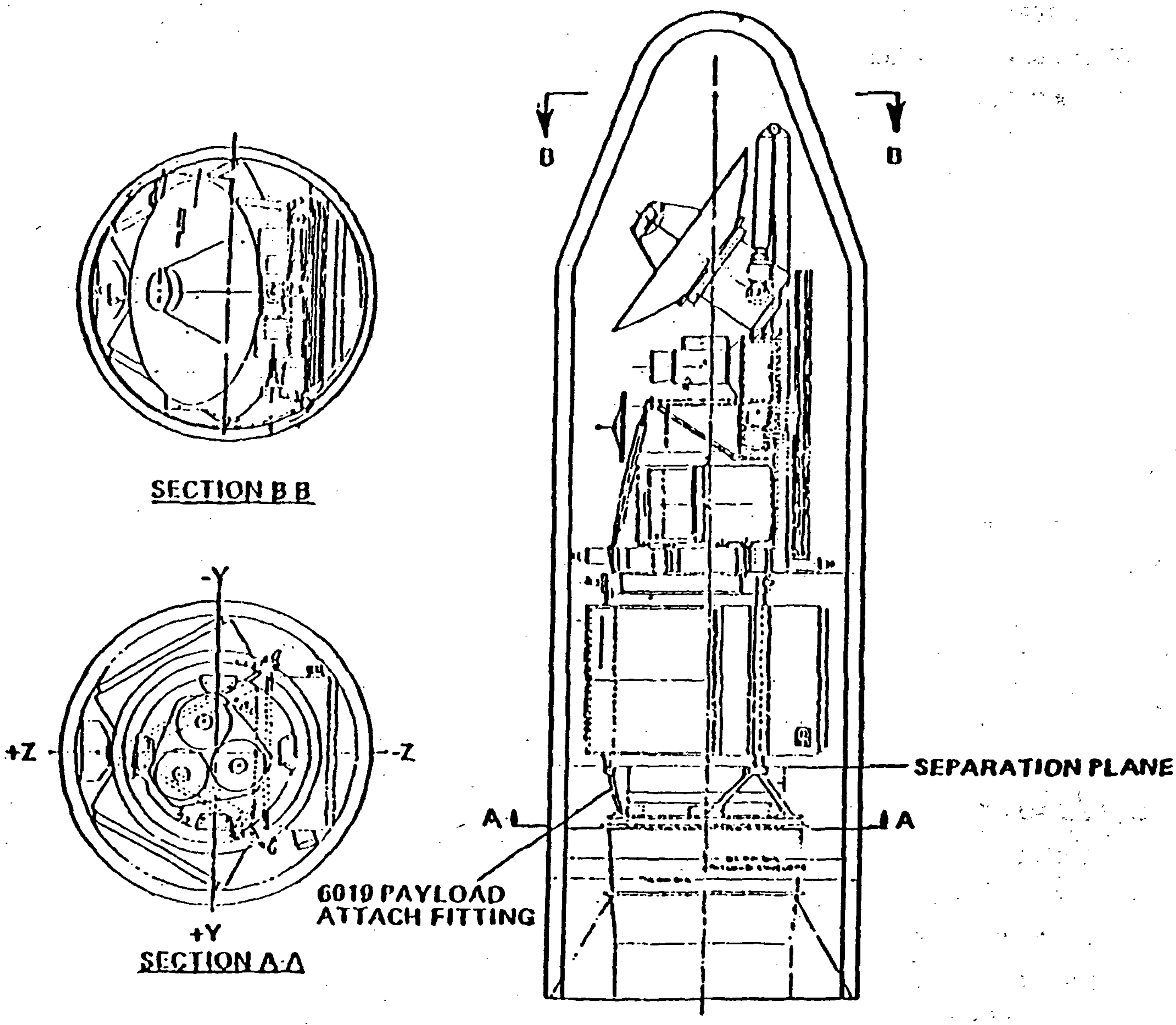
Separation will be followed by solar array deployment, approximately 13 minutes later. Earth pointing and solar array rotation will be initiated during the first full orbit.

Orbit adjust maneuvers to position the spacecraft on its nominal ground track are planned to begin on day 6 and will require about six days to complete.

The multispectral scanner will be activated on orbit 34 (day 4). Each band will be turned on separately. Bands 1 through 4 of the thematic mapper will be sequentially activated on orbit 71 (day 6). Bands 5 through 7 will undergo an outgassing period after the orbit maneuvers are completed. A sequential activation of bands 5 through 7 will occur about day 36.



DELTA LAUNCH CONFIGURATION



EARLY ORBIT TIMELINE

EVENT DAY (FROM LAUNCH)(o=operational)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SOLAR ARRAY DEPLOYMENT	+													
SOLAR ARRAY ROTATION	o													
ATTITUDE CONTROL ACTIVATION	+	o												
STAR CATALOG LOAD		+		o										
EPHEMERIS LOAD		+	o											
SENSOR ACTIVATION														
S BAND MSS				+/o										
X BAND MSS				+/o										
X BAND TM (1-4)					+/o									
X BAND TM/MSS					+/o									
X BAND TM (1-4)/MSS & S BAND MSS							+/o							
S, Ku BAND MSS & 85 mbps							+/o							
X, Ku BAND TM (1-4) & MSS								+/o						
S, X, Ku BAND TM & MSS								+/o						
S BAND MSS TO GDS								o						
TM (5-7) OUTGASSING													+	
TM (5-7) COOLDOWN														-day 35
TM (5-7) COOLDOWN ENDS														-day 36
X BAND TM (5-7)														-day 36
GLOBAL POSITIONING SYSTEM														
LANDSAT ALMANAC LOAD								+						
NDS ALMANAC LOAD								+						
NAVIGATE MODE								+						
HIGH GAIN ANTENNA/BOOM														
DEPLOYMENT						+								
INITIAL POSITIONING						+								
INITIAL PRE-TDRSS EXERCISE											+			
PROGRAM TRACK VALIDATION										+				
ORBIT INJECTION ERROR REMOVAL														
CAL BURNS							+							
MAJOR BURN									+		+			
TRIM (DRAG MAKEUP)														+ +

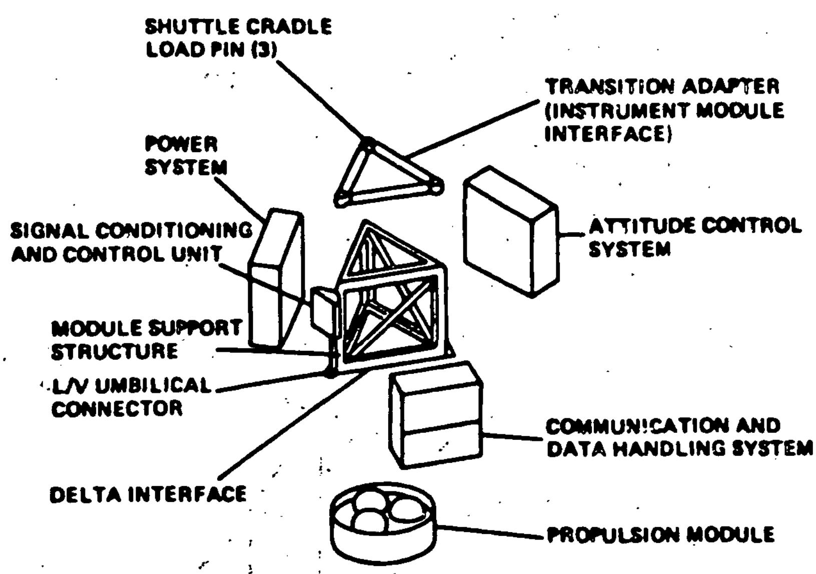
SPACECRAFT DESCRIPTION

The main body of the spacecraft consists of NASA's standard multimission modular spacecraft (MMS) and the Landsat instrument module (IM). The long dimension of the spacecraft body (roll axis) lies in the plane of the orbit. The yaw axis is oriented to the local vertical (parallel to the antenna mast). The pitch axis is normal to the orbit plane and parallel to the axis of rotation of the solar array.

Principal spacecraft measurements follow:

Weight	1941 kg (4273 lb.)
Launch weight margin	127 kg (280 lb.)
Orientation control	three axis momentum wheels
Power	at mission start = 990 watts at end of mission = 814 watts

MULTIMISSION MODULAR SPACECRAFT

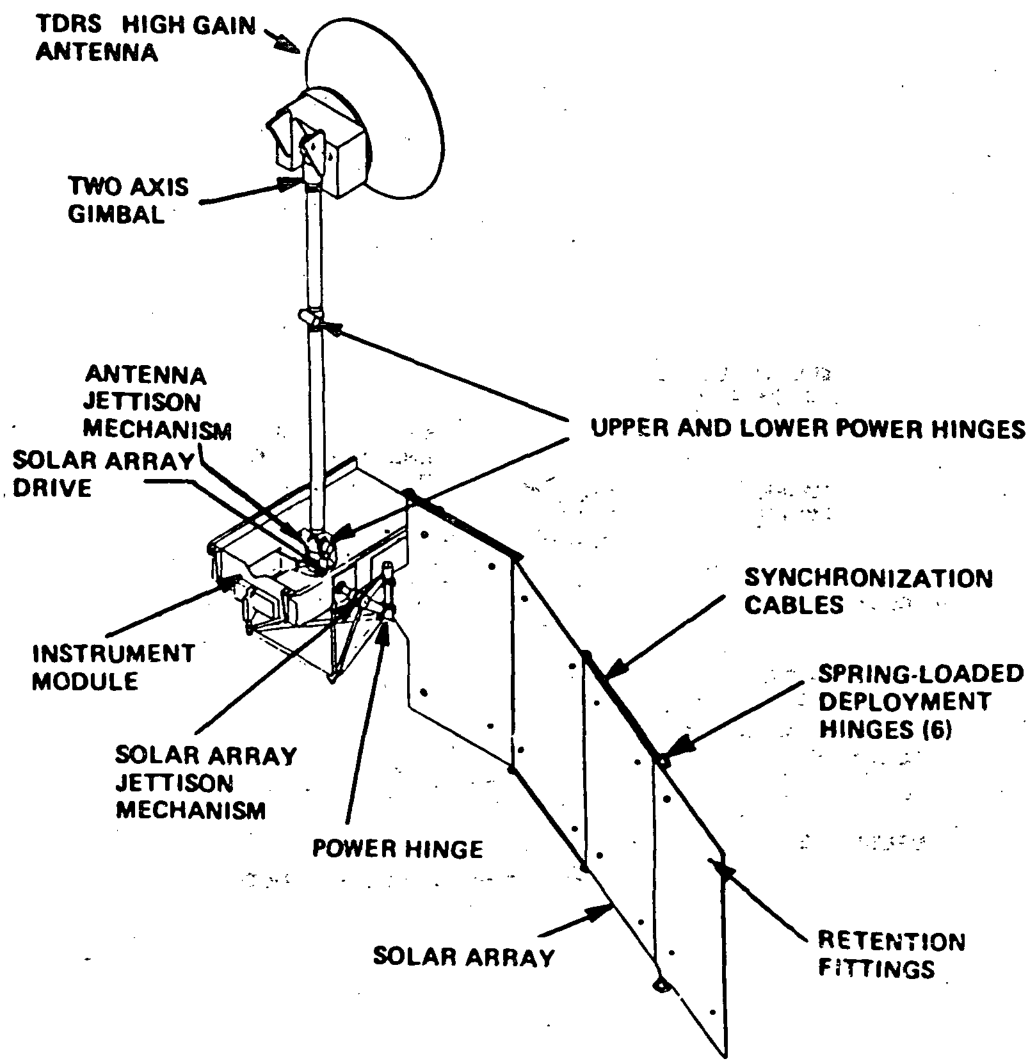


The principal instruments are the thematic mapper, located at the transition adapter between the instrument module and the multimission modular bus, and the multispectral scanner which is located at the forward end of the instrument module. Each instrument uses an oscillating mirror to scan the Earth's surface in the cross-track direction (perpendicular to the spacecraft ground track). The motion of the spacecraft along the ground track provides the along-track scan.

The thematic mapper uses a multistage passive radiator cooler for temperature control of the thermal band detectors. The cooler is on the opposite side from the Sun.

The mast mount for the TDRSS communications assembly extends about 4 m (13 ft.) above the spacecraft body to provide a clear field-of-view to the relay satellite from horizon to horizon. An L-band antenna mounted on this mast provides a link with the global positioning system satellites.

The solar array, with its single axis of rotation drive mechanism, moves at orbital track rate to follow the Sun. It incoporates a fixed bend in the mount to orient the solar collectors perpendicular to the Sun.



MULTIMISSION MODULAR SPACECRAFT

The multimission scanner bus provides four subsystems; power, attitude control, communications and data handling, and propulsion. They are all mounted on a triangular structure. The power, attitude control and comm/data subsystems are housed in identical 1.2 by 1.2 by .3 m (48 by 48 by 12 in.) structures. The forward end of the structure provides the mating surface for the mission-unique portion of the spacecraft and the aft end provides the space and mounting for the propulsion module.

For Delta launches, the structure also provides the mechanical interface to the launch vehicle using an adapter mated to the aft end of the spacecraft.

For retrieval in space, three trunions at the forward end mate to a support cradle which would be carried in the shuttle payload bay.

Power Subsystem

The modular power subsystem receives electrical power from the solar array and conditions, regulates and controls this power for spacecraft use. During periods when the solar array is shadowed by the Earth, batteries supply spacecraft power. The batteries also supplement solar array power during periods of peak power demand.

Communications and Data Handling Subsystem

The comm/data subsystem provides telemetry data at two data rates, 8 kilobits/second during normal operations (with a 1 kbps backup capability for use during launch and in emergencies) and a 32 kbps rate for onboard computer memory dumps to ground and payload correction data transmissions. Two standard tape recorders are included for recording and subsequent playback of telemetry data.

Command is handled by a separate element of the subsystem and provides serial and pulse command capability. All communications between Landsat D and the ground takes place through comm/data subsystem with the exception of the wideband sensor data.

The comm/data subsystem also contains an onboard computer system with 64 kilobits of computer memory. The capability exists to reload onboard memory from the ground and to verify contents of the memory from the ground. The computer is used for attitude control, high gain antenna pointing/control, spacecraft/TDRSS/solar ephemeris computation, failure detection and correction and a variety of housekeeping telemetry functions.

Attitude Control Subsystem

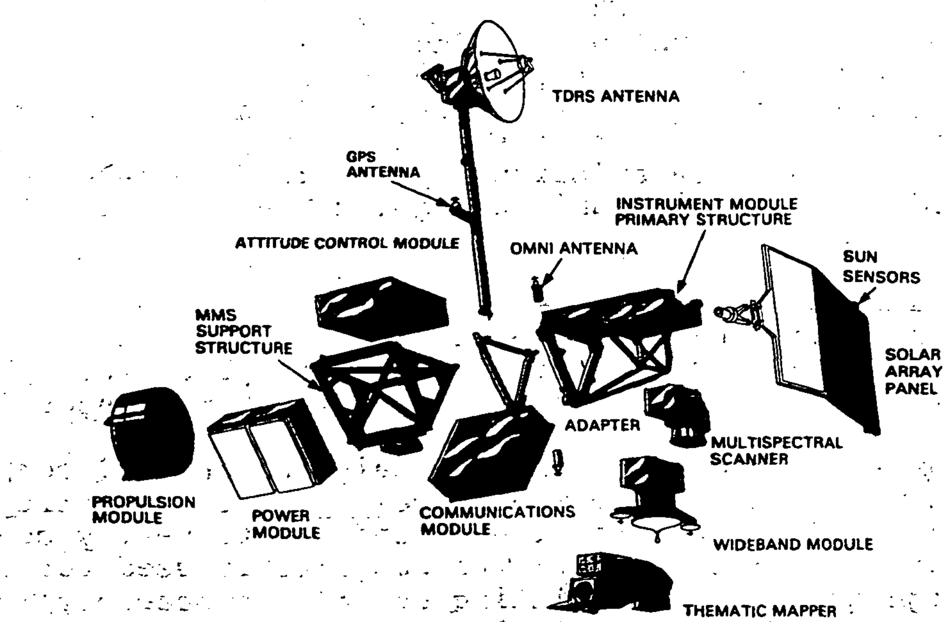
This subsystem is a high precision, zero momentum system with three-axis pointing accuracy to .01 degree with a drift rate of less than .000001 degree/second (10^{-6} degree/sec). The subsystem achieves this level of precision using an inertial reference unit with attitude updates from two star trackers.

A three-axis magnetometer and torquer magnets continuously dump accumulated momentum from the momentum wheels. Backup momentum dumping is available from the propulsion module.

Should the onboard system fail, a "safehold" mode is built in to maintain the spacecraft in an Earth pointing position without the onboard computer. This system uses redundant Earth horizon sensors as a two-axis (pitch/roll) reference system with a gyrocompass for yaw reference.

Propulsion Module

This subsystem is mounted on the aft end of the spacecraft. It uses hydrazine fuel and includes both 11 newton (5 lb.) and 0.5 N (0.2 lb.) thrusters. The large thrusters are used to make orbit adjustments to maintain the 16 day repeat cycle. The large thrusters are also used for the orbit altitude changes needed for Shuttle rendezvous (for retrieval). The small thrusters are used for initial stabilization and for backup momentum dumping.



Global Positioning System

The global positioning system aboard the Landsat D spacecraft includes the L-band antenna (mounted on the TDRSS antenna mast), a preamplifier, oscillator and a receiver/processor assembly. The system receives messages which are transmitted continuously from the orbiting navigation satellites. It then selects the optimum (based on signal strength, signal/noise ratio) set of satellites from which to use data and calculates a three dimensional position and spacecraft velocity for the Landsat D.

The global positioning system is very similar to the tactical air navigation system now used by both military and civilian aircraft. The GPS navsats are expected to be used eventually by many of the same current users of TACAN.

In the early 1980s only six of the planned 18 navigation satellites will be in orbit. Consequently there will be periods of an orbit when there are no navsats within view of the Landsat. During these occulting periods the receiver/processor will estimate position and velocity of the Landsat D using stored data from the previous navsat communication.

Landsat D is the first NASA spacecraft to use the navsat system. Consequently, an experimental period is planned for the first several months of mission operations. During this period ephemeris accuracies from the navsat system will be evaluated and overall performance of the subsystem assessed.

Communications Links

Landsat D uses a wide variety of communications systems to fulfill its mission. Narrowband (low bit rate S band) is used for housekeeping telemetry, command and tracking. Wideband (high bit rate Ku band) is used for Earth observation data communication for both the thematic mapper and the multispectral scanner. Global positioning system communications is used for navigation and time computations.

Both S and Ku band communications are transmitted through the high gain antenna to the relay satellite. S band data is also transmitted through omnidirectional antennas for ground spacecraft tracking and data network use (until the TDRSS is launched this is the only path available for housekeeping/command/control communication).

Existing foreign ground stations are equipped to receive 15 megabits/second multispectral scanner data through S band. However, the S band allocation on Landsat is inadequate to handle the 84.9 mbps necessary for thematic mapper communication. To service foreign ground stations, the Landsat D uses an X band transmitter which can be received by upgraded ground stations.

Wideband Communications (Earth resources data)

The wideband communication subsystem enables the spacecraft to transmit thematic mapper and multispectral scanner data to both the relay satellite and to ground stations. It further enables the spacecraft to acquire and track the relay satellite.

It consists of the radio frequency (RF) compartment, wideband module and gimbal drive assembly. The RF compartment is integrally mounted on a 1.8 m (6 ft) Ku band high gain antenna. The RF component contains the Ku band automatic tracking receiver front end assembly and all components associated with the transmitter.

The wideband module contains the mode selection and modulation equipment used for both the Ku and X band links. It also contains the RF front end for the X band equipment. The S band transmitters are mounted in the instrument module above the wideband module. The S band antenna is mounted on the wideband module next to the X band antenna.

All RF, dc power and signal lines interconnecting the RF compartment and the wideband module are contained in a redundant cable set. To prevent excessive attenuation within the coaxial cables, the signals are sent at S band frequencies to the RF compartment.

MULTISPECTRAL SCANNER

The multispectral scanner aboard Landsat D is very similar to that flown on Landsat 1, 2 and 3. The optics and scan mechanism have been modified to account for the lower altitude of the Landsat D orbit.

The optics are a Ritchey-Cretien type focusing the scanned Earth image on a set of detectors. The instrument includes four spectral bands in the visible and near-infrared portions of the spectrum. Bands 1 through 3 use photomultiplier tubes as detectors. Band 4 uses silicon photo diodes. Each band has six detectors for a total of 24 detectors in the multispectral scanner.

The multispectral scanner scans cross track swaths of 185 km (115 mi.) imaging six scan lines across in each of the four spectral bands simultaneously (for a 24 scan line total). The telescope object plane is scanned by means of an oscillating flat mirror located between the scene and the double-reflector optical chain. The 14.9 degree cross track field of view is obtained as the mirror oscillates.

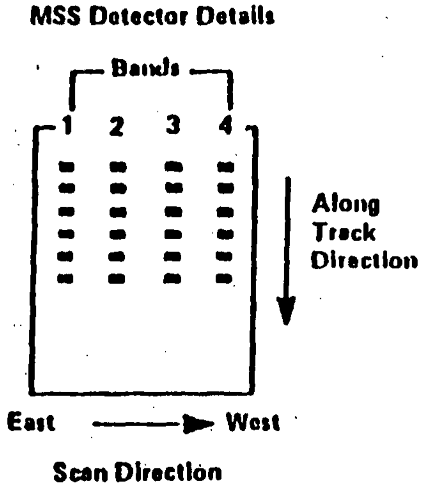
The instantaneous field of view of each detector subtends an Earth area square of 83 m (272 ft.) on a side from the nominal orbital altitude. Field stops are formed for each line imaged during a scan and for each spectral band.

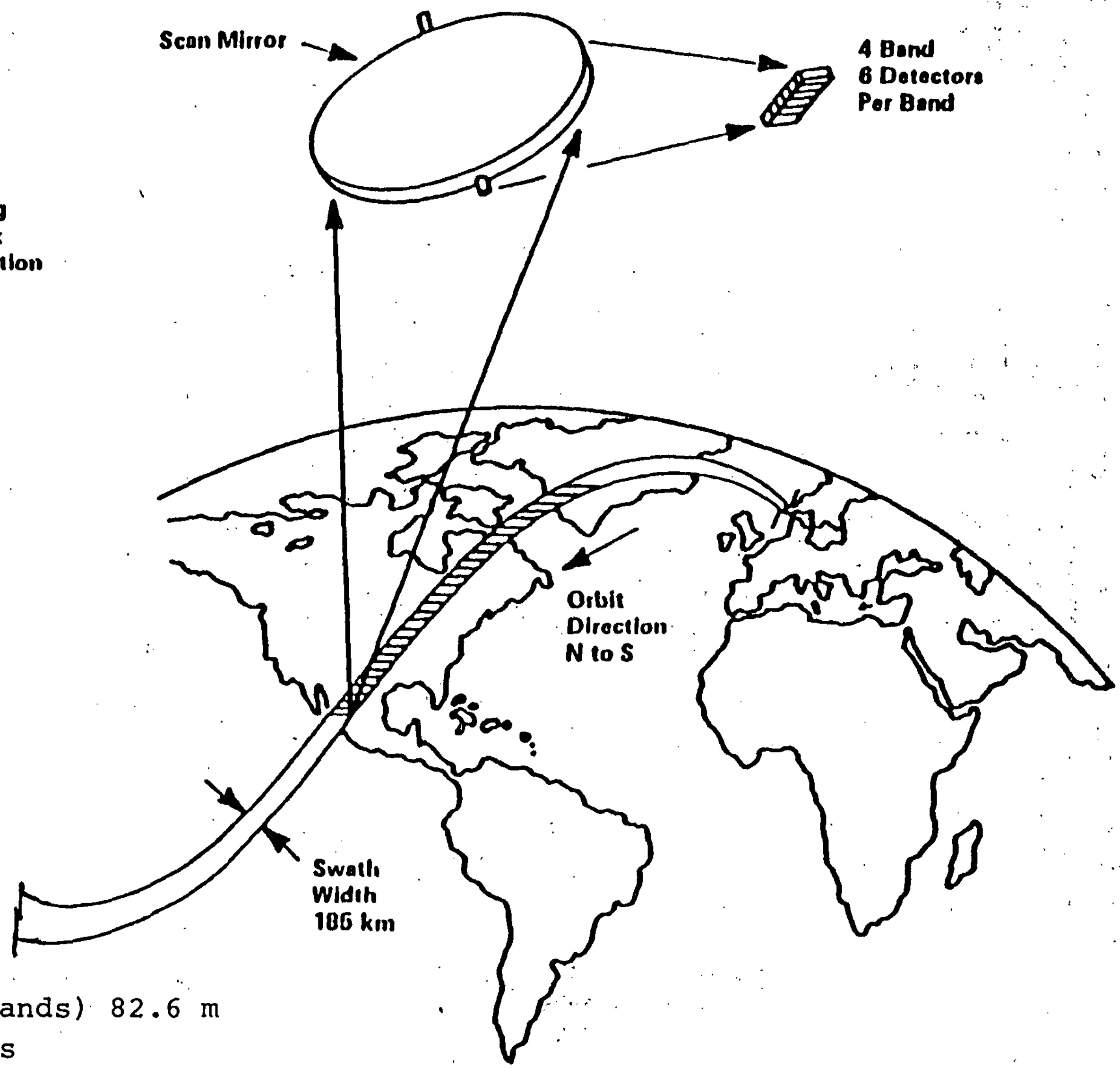
These stops are the square input end of an optical fiber. Six of these fibers in each of the four bands are arranged in a 4 by 6 matrix in the focused area of the telescope.

Light impinging on each glass fiber is conducted to an individual detector through an optical filter, unique to the spectral band that detector is assigned to cover. An image of a line across the swath is swept across each time the mirror scans, causing a video signal to be produced at the multispectral scanner electronics for each of the 24 channels. These signals are then sampled, digitized and formatted into a serial data stream by the multispectral scanner multiplexer. The signals in bands 1 and 2 can be amplified by a factor of three (upon command) to increase response to low level scene radiance.

The along track scan is produced by the orbital motion of the spacecraft itself. The nominal velocity causes an along track motion of the subsatellite point on Earth of 6.82 km/sec (4.23 m./sec - 15,228 mph)(not counting orbital perturbation and Earth rotation effects). By oscillating the mirror at a rate of 13.62 Hz the subsatellite point will have moved 496 m (1,627 ft) along the track during the 73.42 millisec active scan and retrace cycle.

Multispectral Scanner (MSS) Sensor





Band	Spectral Ranges μm
1	.5 – .6
2	.6 – .7
3	.7 – .8
4	.9 – 1.1

Ground IFOV (all bands) 82.6 m
Data rate = 15 mbps
Quantization level = 64

THEMATIC MAPPER

The thematic mapper is a seven band multispectral high resolution scanner. The instrument consists of a scanning mechanism, primary imaging optics, spectral band discrimination optics, detectors, radiative cooler, inflight calibration device and operating/processing electronics.

It will collect, filter and detect radiation from Earth in a swath 185 km (115 mi.) wide. The variation in radiant flux passing through the field stop onto the detectors creates an electrical output which represents the radiant history of that scan line.

The thematic mapper quantizes and multiplexes signals from all of its detectors into a serial data stream for transmission.

Radiant energy (visible and thermal infrared) enters the instrument through the Sun-shaded aperture. Scanning of the field is accomplished by the scan mirror in the cross track direction and by the motion of the spacecraft in the along track direction.

The scan mirror is a 0.4 by 0.53 m (16 by 21 in.) ellipse which presents an equal area at all scan angles. The scan mirror moves the view of the telescope back and forth across the ground track.

The ground track is divided into 16 raster (scan) lines as it is scanned. There are 16 detectors for each of six bands and four detectors for the seventh band. The band 7 detectors are four times the area of the bands 1 through 6 detectors.

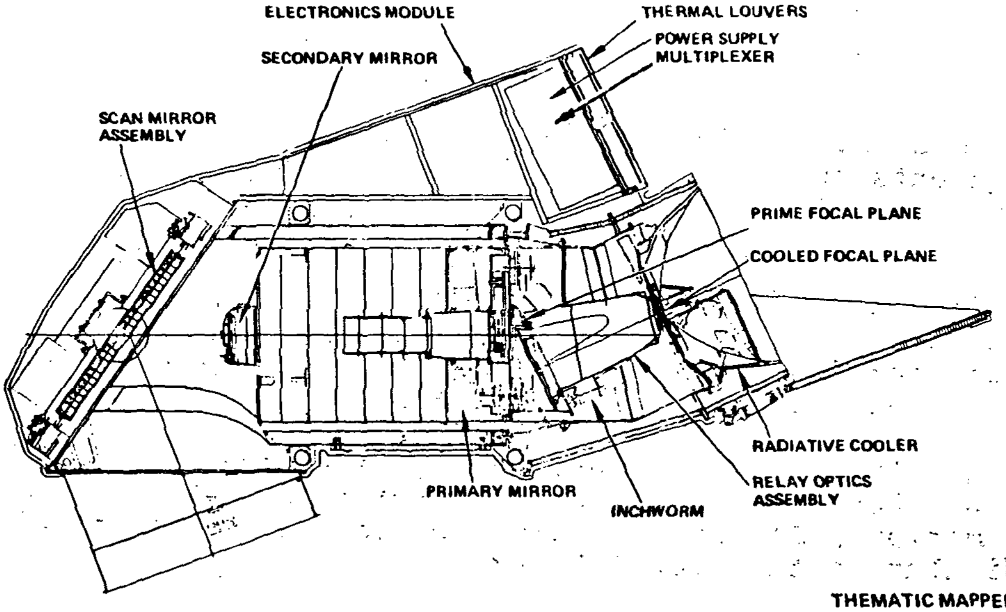
A scan line corrector preceding the detectors compensates for the southerly drift of the detector swath due to spacecraft orbital motion. Because of this the scan lines are straight and perpendicular to the ground track.

Both directions of the scanning mirror are used for a high scan efficiency. The corrector jumps ahead during the scan mirror turnaround so that the next set of scan lines is contiguous with the previous set.

Because of this correction, the seven sets of detectors representing the seven bands are effectively scanned across the same fixed Earth point, although at a different time. Because of this, time correction is important also. The mirror is controlled and damped to move linearly and repeatably in order to provide geometrically accurate data.

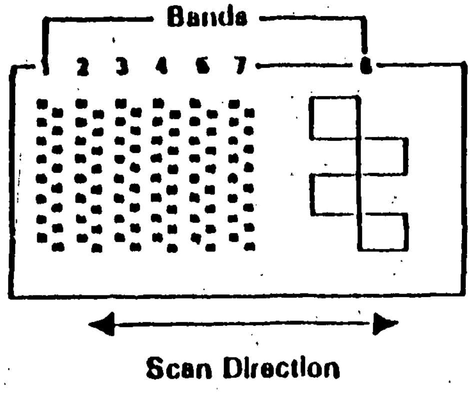
The detector package for the visible and near infrared bands (1,2,3 and 4) consists of four linear arrays of 16 silicon photo diode detectors, each located at the uncooled telescope focal plane. The optics are of a Ritchey-Cretien telescope design.

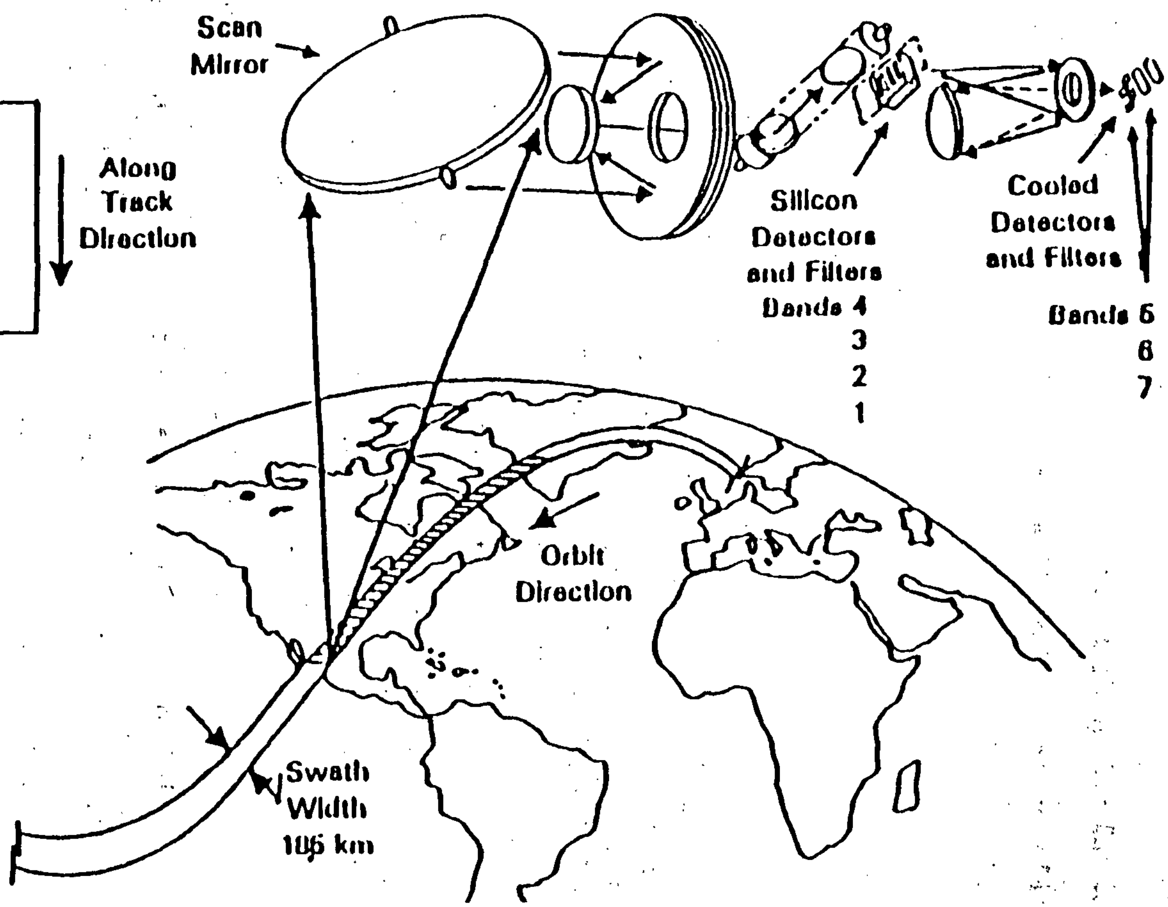
The mid-infrared bands (5 and 7) consist of 16 indium-antimonide photo diodes each. The far (thermal) infrared band (6) consists of four mercury-cadmium-telluride detectors. The sensors for bands 5, 6 and 7 are located at the cooled telescope focal plane. Detector signals are amplified, filtered and routed to the thematic mapper multiplexer which digitizes the information, adds synchronization signals, timecode information, mirror position information and telemetry and forwards to the wideband communications subsystem.



THEMATIC MAPPER

THEMATIC MAPPER (TM) SENSOR





BAND	SPECTRAL RANGES μm
1	.45 – .52
2	.52 – .60
3	.63 – .69
4	.76 – .90
5	1.55 – 1.75
6	10.4 – 12.5
7	2.08 – 2.35

Ground IFOV
  Band 1-5,7 = 30 m
  Band 6 = 120 m
Data Rate = 84.9 mbps
Quantization level = 256

LANDSAT D GROUND PROCESSING SYSTEM

The Landsat D ground system consists of a series of separate component systems and is located at the Goddard Space Flight Center:

Control and simulation facility

This facility schedules spacecraft operations and communications network support, generates and transmits commands, acquires and processes spacecraft telemetry, monitors and evaluates spacecraft performance and includes a full spacecraft simulator for use in training and for failure analysis.

Multispectral scanner mission management facility

This facility is the central production control area for all ground operations associated with the multispectral scanner. Functions include processing requests for image products from users, maintaining a central data base of user requests, image data acquisitions and products generated, scheduling the image correction and product generation processes, controlling the shipment of products, controlling inventory and management reports.

Multispectral scanner image processing system

This facility processes correction data used in the image generation process, generates image products on high density digital tape, computer compatible tape and film. It also calculates the radiometric corrections necessary and computes the geometric corrections and adds these to the archive tapes.

Thematic mapper mission management facility

This is the central production area for all ground thematic mapper operations. Functions are similar to those of the multispectral scanner management facility.

Thematic mapper image processing system

The functions of this facility are similar to those of the multispectral scanner image processing system but require much faster computer equipment and more complex computer software due in part to the higher data rates associated with the thematic mapper (84.6 mbps for the thematic mapper versus 15 mbps for the multispectral scanner). This facility is not expected to be online until mid 1983.

Data receive, record and transmit system

This facility acquires and records the high bit rate digital data received from the relay satellite or GSTDN ground stations. It also creates directories identifying the content of the data received and includes equipment for transmitting received, processed, data to the EROS Data Center.

Transportable ground station

This facility is an X band and S band receiving station at Goddard Space Flight Center. It receives the high bit rate digital data and thematic mapper and multispectral scanner instrument data directly from the Landsat D spacecraft. It forwards received data to the data receive, record and transmit system and is the primary thematic mapper receiving station until the relay satellite becomes operational in 1983. Following TDRSS operations, the transportable ground station will be used for engineering evaluations.

Landsat assessment system

This facility is not part of the online Landsat D processing system. It is used for research and development work associated with the thematic mapper evaluation. It will be used for developing thematic mapper analysis techniques in selected Earth resources disciplines. During the first year of thematic mapper operations, this facility will also be used to process thematic mapper images up to one scene per day.

NASA LANDSAT D PROGRAM MANAGEMENT

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Dr. Stanley I. Weiss	Associate Administrator for Space Transportation Operations
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Joseph B. Mahon	Director, Expendable Launch Vehicles Division
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Goddard Space Flight Center

Dr. Noel W. Hinners	Director
William C. Keathly	Director, Project Management
Jon R. Busse	Project Manager, Landsat D
Luis Gonzales	Deputy Project Manager, Landsat D
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Dr. Vincent Salomonson	Project Scientist, Landsat D
Albert Lunchick	Flight Assurance Manager, Landsat D
Joseph R. Schulman	Systems Manager, Landsat D
Joseph Arlauskas	Systems Manager, Instruments, Landsat D
Lottie E. Brown	Software Manager, Landsat D

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Goddard Center (cont'd.)

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William C. Webb	Mission Operations Manger, Landsat D
Richard A. Devlin	Spacecraft Manager, Landsat D
Oscar Weinstein	Instrument Systems Manager, Landsat D
David W. Grimes	Delta Project Manager
William R. Russell	Deputy Delta Project Manager, Technical
J. Donald Kraft	Manager, Delta Mission Analysis and Integration
Warner H. Hord Jr.	Landsat Mission Integration Manager
Robert I. Seiders	Mission Operations and Network Support Manager
Ray Mazur	Mission Support

Kennedy Space Center

Richard G. Smith	Director
Thomas S. Walton	Director, Cargo Operations
Charles D. Gay	Director, Expendable Vehicles Operations Directorate
Wayne L. McCall	Chief, Delta Operations Division
Ray Kimlinger	Chief, Delta Western Operation Branch
Pat Murphy	Manager, STS Resident Office (VAFB)
C. R. Fuentes	Spacecraft Coordinator

National Oceanic and Atmospheric Administration (NOAA)

Dr. John V. Byrne	Administrator
Dr. Anythony J. Calio	Deputy Administrator
James W. Winchester	Associate Administrator

NOAA National Earth Satellite Service

Dr. John H. McElroy	Assistant Administrator for Satellites
Harold Yates	Acting Deputy Assistant Administrator for Satellites
E. Larry Heacock	Director, Office of Systems Development
Russell Koffler	Director, Office of Data Services
Edward F. Conlan	Chief, Landsat Operations Division, Office of Data Service

CONTRACTORS

General Electric Co. Space Systems Division Valley Forge, Pa.	Landsat D spacecraft Landsat D ground system
Hughes Aircraft Co. Los Angeles, Calif.	Thematic Mapper Multispectral Scanner
Fairchild Industries Fairchild Space & Electronics Germantown, Md.	Multimission Modular Spacecraft
McDonnell Douglas Corp. McDonnell Douglas Astronautics Co. Huntington Beach, Calif.	Delta 3920 launch vehicle Payload Assist Module (PAM) Payload Stage
Rockwell International Rocketdyne Div. Canoga Park, Calif.	Delta first stage engine (RS-27)
Thiokol Corp. Huntsville, Ala.	Castor IV strap-on engines
Aerojet Liquid Rocket Sacramento, Calif.	AJ10-118K (ITIP) second stage engine
General Motors Corp. Delco Div. Santa Barbara, Calif.	Guidance computer

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